

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

SHINTANI et al.

Application No. Unassigned Art Unit: Unassigned

Filed: August 22, 2001 Examiner: Unassigned

For: METHOD OF
FABRICATING
SEMICONDUCTOR
DEVICE AND WAFER
TREATMENT
APPARATUS
EMPLOYED THEREFOR
AS WELL AS
SEMICONDUCTOR
DEVICE

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D. C. 20231

Dear Sir:

Prior to the examination of the above-identified patent application, please enter the following amendments and consider the following remarks.

IN THE SPECIFICATION:

Replace the paragraph beginning at page 1, line 15, with:

High performance is required particularly in a transistor employed for a logic circuit or a system LSI (large-scale integrated circuit) among semiconductor devices. In order to satisfy this requirement, the thickness of a gate insulation film of the transistor is set to not more than 3 nm. Further, a development has recently been made for reducing the thickness of the gate insulating film below 2 nm.

Replace the paragraph beginning at page 2, line 10, with:

The polysilicon film is etched through the mask member in an atmosphere prepared by converting a gas mixture containing Cl_2 and O_2 or HBr , Cl_2 and O_2 , for example, into a plasma, patterning the gate electrode. In this patterning, a reaction product adheres to the side wall surfaces of the gate electrode and the surface of the mask member. After formation of the gate electrode, the reaction product adhering to the gate electrode is removed by wet cleaning.

Replace the paragraph beginning at page 2, line 17, with:

It is known that the reaction product is mainly composed of a silicon oxide such as SiO_xCl_y or SiO_xBr_y when the polysilicon film is etched by converting the gas mixture containing Cl_2 and O_2 or HBr , Cl_2 , and O_2 to a plasma.

Replace the paragraph beginning at page 3, line 26, with:

In this case, the etched portion may not be fully filled but produce a void when the gate electrode 103 is covered with an interlayer isolation film, and reduce the reliability of the semiconductor device.

IN THE CLAIMS

Replace the indicated claims with:

1. (Amended) A method of fabricating a semiconductor device comprising a wafer treatment of a first part of the wafer having a first etching property and a second part of the wafer having a second etching property different from the first etching property, in a chamber with a gas for etching, including:

introducing the gas for etching into the chamber, and

assuming that a time between introduction of the gas for etching into the chamber and starting of etching of the first part of the wafer is a first starting time, and a time between introduction of the gas for etching into the chamber and starting of etching of the second part of the wafer is a second starting time, longer than said first starting time, supplying the gas for etching for a time longer than the first starting time but shorter than the second starting time.

2. (Amended) The method of fabricating a semiconductor device according to claim 1, wherein the time difference between the first starting time and the second starting time is not more than about 5 seconds.

3. (Amended) The method of fabricating a semiconductor device according to claim 1, further comprising:

forming a gate insulating film on the semiconductor substrate, and

forming a gate electrode on the insulating film, wherein the first part of the wafer contains a reaction product generated before forming the gate electrode, covering the gate insulating film and the gate electrode,

the second part includes said gate insulating film, and

the gas for etching includes hydrofluoric acid.

4. (Amended) The method of fabricating a semiconductor device according to claim 1, including introducing a reaction accelerating gas into the chamber before introducing the gas for etching for reducing the first starting time.

5. (Amended) The method of fabricating a semiconductor device according to claim 4, including alternately introducing the reaction accelerating gas and the gas for etching.

6. (Amended) The method of fabricating a semiconductor device according to claim 4, including continuously adding the reaction accelerating gas after starting supply of the gas for etching.

7. (Amended) The method of fabricating a semiconductor device according to claim 1, including evacuating the chamber, but not while the gas for etching is being supplied.

8. (Amended) The method of fabricating a semiconductor device according to claim 1, further comprising:

forming a conductive layer on a gate insulating film on the semiconductor substrate,

forming a layer for defining a mask on the conductive layer,

etching the conductive layer through a mask of the layer for defining a mask, thereby forming a gate electrode, and

removing the layer for defining a mask remaining on the gate electrode after formation of the gate electrode, wherein

the first part of the wafer includes the layer for defining a mask,

the second part of the wafer includes the gate insulator film, and

hydrofluoric acid gas is supplied as the gas for etching to remove the layer for defining a mask.

9. (Amended) The method of fabricating a semiconductor device according to claim 8, including repeatedly supplying the gas for etching.

10. (Amended) The method of fabricating a semiconductor device according to claim 9, including evacuating the chamber, and alternatively supplying the gas for etching and evacuating the chamber.

11. (Amended) A wafer treatment apparatus for treating a first part of the wafer having a first etching property and a second part of the wafer having a second etching property, different from the first etching property with a gas for etching, comprising:

a chamber for holding a wafer;

an etching gas supply part supplying the gas for etching into said chamber; and

a control part controlling supply of the gas for etching from said etching gas supply part into said chamber, wherein said control part, assuming that a time between introduction of the gas for etching into said chamber and starting of etching of the first part of the wafer is a first starting time and a time between introduction of the gas for etching into said chamber and starting of etching of the second part of the wafer is a second starting time, longer than the first starting time, supplies the gas for etching from said etching gas supply part into said chamber for a time longer than the first starting time but shorter than the second starting time.

12. (Amended) The wafer treatment apparatus according to claim 11, wherein the time difference between the first starting time and the second starting time is not more than about 5 seconds.

13. (Amended) The wafer treatment apparatus according to claim 11, further comprising an added gas supply part supplying a reaction accelerating gas, for reducing the first starting time, into said chamber, wherein said control part supplies the reaction accelerating gas from said added gas supply part into said chamber before supplying the gas for etching.

14. (Amended) The wafer treatment apparatus according to claim 13, wherein said control part alternately supplies the gas for etching and the reaction accelerating gas.

15. (Amended) The wafer treatment apparatus according to claim 13, wherein said control part supplies the reaction accelerating gas while supplying the gas for etching.

16. (Amended) The wafer treatment apparatus according to claim 11, further comprising an evacuation part evacuating said chamber, wherein said control part prevent said evacuation part from operating while supplying the etching gas.

17. (Amended) A method of cleaning a wafer after formation of a gate electrode, including removing a reaction product formed by etching with hydrofluoric acid gas, after forming the gate electrode that has been patterned by the etching with a mask on a semiconductor substrate, through a gate insulating film.

18. (Amended) The cleaning method according to claim 17, including removing the reaction product with hydrofluoric acid gas within a reaction time difference between a time when the reaction product is etched by the hydrofluoric acid gas and a time when the gate insulating film is etched by the hydrofluoric acid gas.

19. (Amended) The cleaning method according to claim 18, wherein the reaction time difference is repetitively set, thereby removing the reaction product with the hydrofluoric acid gas.

20. (Amended) The cleaning method according to claim 19, wherein a semiconductor substrate including the gate electrode is set in a chamber, and the reaction time difference is repetitively set by repeatedly evacuating the chamber and charging the chamber with the hydrofluoric acid gas.

IN THE ABSTRACT

Replace the abstract with:

ABSTRACT OF THE DISCLOSURE

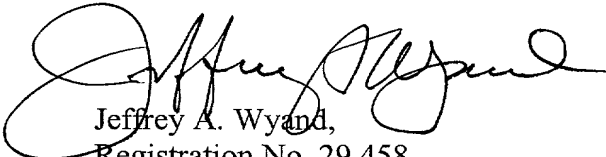
In a wafer treatment apparatus, a hydrofluoric acid gas supply pipe and an evacuation pipe are connected to a chamber holding a wafer for performing a treatment. A control part controls supply of hydrofluoric acid gas. The control part sets a time for supplying the hydrofluoric acid gas into the chamber that is longer than a time until starting of etching of a reaction product and shorter than a time until starting of etching of a gate insulating film. Thus, the reaction product can be substantially etched without etching the gate insulating film.

REMARKS

The foregoing amendments are made to correct minor translational errors and to meet United States requirements as to form. No new matter is added.

Respectfully submitted,

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**AMENDMENTS TO SPECIFICATION, CLAIMS, AND
ABSTRACT MADE VIA PRELIMINARY AMENDMENT**

Amendments to the paragraph beginning at page 1, line 15:

High performance is required particularly ~~to~~ in a transistor employed for a logic circuit or a system LSI (large-scale integrated circuit) among semiconductor devices. In order to satisfy this requirement, the thickness of a gate ~~insulator~~ insulation film of the transistor is set to not more than 3 nm. Further, a development is has recently been made for reducing the thickness of the gate ~~insulator~~ insulating film below 2 nm.

Amendments to the paragraph beginning at page 2, line 10:

The polysilicon film is etched through the mask member in an atmosphere prepared by converting a gas mixture containing Cl₂ and O₂ or HBr, Cl₂ and O₂, for example, ~~to into a plasma thereby~~, patterning the gate electrode. In this patterning, a reaction product adheres to the side wall surfaces of the gate electrode and the surface of

the mask member. After formation of the gate electrode, the reaction product adhering to the gate electrode is removed by wet cleaning.

Amendments to the paragraph beginning at page 2, line 17:

It is known that the reaction product is mainly composed of a silicon oxide such as SiO_xCl_y or SiO_xBr_y when the polysilicon film is etched by converting the gas mixture containing Cl_2 and O_2 or HBr , Cl_2 , and O_2 to a plasma in particular.

Amendments to the paragraph beginning at page 3, line 26:

In this case, the etched portion may not be fully filled up but define produce a void when the gate electrode 103 is covered with an interlayer isolation film, ~~to~~ and reduce the reliability of the semiconductor device.

Amendments to the existing claims:

1. (Amended) A method of fabricating a semiconductor device comprising a wafer treatment ~~step performing prescribed treatment on~~ of a first part of the wafer having a ~~prescribed first~~ etching property and a second part of the wafer having an a second etching property different from ~~said prescribed the first etching property, formed on a semiconductor substrate,~~ in a chamber with a gas for etching, wherein including:

~~said wafer treatment step includes an etching gas supply step of introducing said the gas for etching into said the chamber, and~~

assuming that a time between introduction of ~~said the~~ gas for etching into said the chamber and starting of etching of ~~said the first part of the wafer is referred to as~~ a first starting time, and a time between introduction of ~~said the~~ gas for etching into said the chamber and starting of etching of ~~said the second part of the wafer is referred to as~~ a second starting time, longer than said first starting time, ~~a time for carrying out said supplying the gas for etching gas supply step is for a time longer than said the first starting time and but shorter than said the second starting time.~~

2. (Amended) The method of fabricating a semiconductor device according to claim 1, wherein the time difference between ~~said the~~ first starting time and ~~said the~~ second starting time is not more than about 5 seconds.

3. (Amended) The method of fabricating a semiconductor device according to claim 1, further comprising ~~steps of~~:

forming ~~an insulator~~ a gate insulating film on ~~said the~~ semiconductor substrate, and

forming ~~a conductive region~~ gate electrode on ~~said insulator~~ the insulating film, wherein

~~said step of forming said insulator film includes a step of forming a gate insulator film,~~

~~said step of forming said conductive region includes a step of forming a gate electrode part on said gate insulator film,~~

said the first part of the wafer contains a reaction product generated before forming ~~said the~~ gate electrode ~~part for~~, covering the ~~surface of said gate insulator~~ insulating film and the ~~surface of said gate electrode part~~,

~~said the~~ second part includes ~~said gate insulator~~ insulating film, and

~~said the~~ gas for etching includes hydrofluoric acid ~~gas~~.

4. (Amended) The method of fabricating a semiconductor device according to claim 1, ~~wherein said wafer treatment step includes an added gas supply step of including~~ introducing a reaction accelerating gas into the chamber before introducing the gas for etching for ~~further~~ reducing ~~said the~~ first starting time ~~into said chamber before said etching gas supply step~~.

5. (Amended) The method of fabricating a semiconductor device according to claim 4, ~~wherein said added gas supply step and said etching gas supply step are~~ including alternately carried out in said wafer treatment step introducing the reaction accelerating gas and the gas for etching.

6. (Amended) The method of fabricating a semiconductor device according to claim 4, ~~wherein said added gas supply step is continuously carried out also after said etching gas~~ including continuously adding the reaction accelerating gas after starting supply step is started in said wafer treatment step of the gas for etching.

7. (Amended) The method of fabricating a semiconductor device according to claim 1, ~~wherein said wafer treatment step includes an evacuation step of including evacuating said the chamber, and said evacuation step is but not carried out at least while the gas for etching gas supply step is carried out being supplied.~~

8. (Amended) The method of fabricating a semiconductor device according to claim 1, further comprising ~~steps of:~~

forming a conductive layer on ~~said semiconductor substrate through a gate insulator~~ insulating film on the semiconductor substrate,

forming a layer for defining a mask on ~~said the~~ conductive layer,

etching ~~said the~~ conductive layer through a mask of ~~said the~~ layer for defining a mask, thereby forming a gate electrode, and

removing ~~said the~~ layer for defining a mask remaining on ~~said the~~ gate electrode after formation of ~~said the~~ gate electrode, wherein

~~said wafer treatment step includes a step of removing said layer for defining a mask,~~

said the first part of the wafer includes ~~said the~~ layer for defining a mask,

said the second part of the wafer includes ~~said the~~ gate insulator film, and

hydrofluoric acid gas is supplied as the gas for etching gas in said etching gas supply step to remove the layer for defining a mask.

9. (Amended) The method of fabricating a semiconductor device according to claim 8, ~~wherein said etching gas supply step is repetitively carried out in said wafer treatment step~~ including repeatedly supplying the gas for etching.

10. (Amended) The method of fabricating a semiconductor device according to claim 9, ~~wherein said wafer treatment step includes an evacuation step including~~ evacuating said the chamber, and ~~said alternatively supplying the gas for etching gas supply step and said evacuation step are alternately carried out~~ evacuating the chamber.

11. (Amended) A wafer treatment apparatus for ~~performing prescribed treatment on~~ treating a first part of the wafer having a ~~prescribed first~~ first etching property and a second part of the wafer having ~~an a second~~ a second etching property, different from ~~said prescribed the first~~ said prescribed the first etching property, ~~formed on a wafer~~, with a gas for etching, comprising:

a chamber ~~storing said~~ for holding a wafer;

an etching gas supply part supplying ~~said the~~ the gas for etching into said chamber;

and

a control part controlling supply of ~~said the~~ the gas for etching from said etching gas supply part into said chamber, wherein said control part ~~has~~, assuming that a time between introduction of ~~said the~~ the gas for etching into said chamber and starting of etching of ~~said the first part of the wafer is referred to as~~ a first starting time and a time between introduction of ~~said the~~ the gas for etching into said chamber and starting of etching of ~~said the second part of the wafer is referred to as~~ a second starting time, longer than ~~said the~~ said the first starting time, ~~a function of supplying said~~ supplies the gas for etching from said etching gas supply part into said chamber ~~by for~~ for a time longer than ~~said the~~ said the first starting time ~~and but~~ but shorter than ~~said the~~ said the second starting time.

12. (Amended) The wafer treatment apparatus according to claim 11, wherein the time difference between ~~said the first starting time and said the second starting time~~ said the first starting time and said the second starting time is not more than about 5 seconds.

13. (Amended) The wafer treatment apparatus according to claim 11, further comprising: an added gas supply part supplying a reaction accelerating gas, for reducing ~~said the first starting time~~ the first starting time, into said chamber, wherein said control part ~~includes a function of supplying said~~ supplies the reaction accelerating gas from said added gas supply part into said chamber before supplying ~~said the~~ the gas for etching.

14. (Amended) The wafer treatment apparatus according to claim 13, wherein said control part ~~includes a function of alternately supplying said~~ supplies the gas for etching and ~~said the~~ reaction accelerating gas.

15. (Amended) The wafer treatment apparatus according to claim 13, wherein said control part ~~includes a function of supplying said~~ supplies the reaction accelerating gas ~~also~~ while supplying ~~said the~~ gas for etching.

16. (Amended) The wafer treatment apparatus according to claim 11, further comprising an evacuation part evacuating said chamber, wherein said control part ~~includes a function of not operating~~ prevents said evacuation part ~~at least from operating~~ while supplying ~~said the~~ etching gas.

17. (Amended) A ~~cleaning~~ method of cleaning a wafer after formation of a gate electrode, including removing a reaction product formed by etching with hydrofluoric acid gas, after forming ~~a the~~ gate electrode that has been patterned by ~~said the~~ etching with a mask on a semiconductor substrate, through a gate insulating film.

18. (Amended) The cleaning method ~~after formation of a gate electrode~~ according to claim 17, ~~wherein the time for~~ including removing ~~said the~~ reaction product with ~~said~~ hydrofluoric acid gas ~~is within the~~ a reaction time difference between a time when ~~said the~~ reaction product is ~~scraped~~ etched by ~~said the~~ hydrofluoric acid gas and a time when ~~said the~~ gate ~~insulator~~ insulating film is ~~scraped~~ etched by the hydrofluoric acid gas.

19. (Amended) The cleaning method ~~after formation of a gate electrode~~ according to claim 18, wherein ~~said the~~ reaction time difference is repetitively set, thereby removing ~~said the~~ reaction product with ~~said the~~ hydrofluoric acid gas.

20. (Amended) The cleaning method ~~after formation of a gate electrode~~ according to claim 19, wherein ~~said a~~ semiconductor substrate ~~formed with said~~ including the gate electrode is set in a chamber, and ~~said the~~ reaction time difference is repetitively

set by ~~repeating steps of~~ repeatedly evacuating ~~said the~~ chamber and charging ~~said the~~ chamber with ~~said the~~ hydrofluoric acid gas.

Amendments to the abstract:

ABSTRACT OF THE DISCLOSURE

In a wafer treatment apparatus, a hydrofluoric acid gas supply pipe and an evacuation pipe are connected to a chamber ~~storing~~ holding a wafer for performing ~~prescribed a~~ treatment. A control part ~~is provided for controlling~~ controls supply of hydrofluoric acid gas. The control part sets a time for supplying the hydrofluoric acid gas into the chamber ~~to be~~ that is longer than a time ~~up to~~ until starting of etching of a reaction product and shorter than a time ~~up to~~ until starting of etching of a gate ~~insulator~~ insulating film. Thus, ~~only~~ the reaction product can be substantially etched without etching the gate ~~insulator~~ insulating film.

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PENDING CLAIMS AFTER ENTRY OF PRELIMINARY AMENDMENT

1. A method of fabricating a semiconductor device comprising a wafer treatment of a first part of the wafer having a first etching property and a second part of the wafer having a second etching property different from the first etching property, in a chamber with a gas for etching, including:

introducing the gas for etching into the chamber, and

assuming that a time between introduction of the gas for etching into the chamber and starting of etching of the first part of the wafer is a first starting time, and a time between introduction of the gas for etching into the chamber and starting of etching of the second part of the wafer is a second starting time, longer than said first starting time, supplying the gas for etching for a time longer than the first starting time but shorter than the second starting time.

2. The method of fabricating a semiconductor device according to claim 1, wherein the time difference between the first starting time and the second starting time is not more than about 5 seconds.

3. The method of fabricating a semiconductor device according to claim 1, further comprising:

forming a gate insulating film on the semiconductor substrate, and

forming a gate electrode on the insulating film, wherein the first part of the wafer contains a reaction product generated before forming the gate electrode, covering the gate insulating film and the gate electrode,

the second part includes said gate insulating film, and

the gas for etching includes hydrofluoric acid.

4. The method of fabricating a semiconductor device according to claim 1, including introducing a reaction accelerating gas into the chamber before introducing the gas for etching for reducing the first starting time.

5. The method of fabricating a semiconductor device according to claim 4, including alternately introducing the reaction accelerating gas and the gas for etching.

6. The method of fabricating a semiconductor device according to claim 4, including continuously adding the reaction accelerating gas after starting supply of the gas for etching.

7. The method of fabricating a semiconductor device according to claim 1, including evacuating the chamber, but not while the gas for etching is being supplied.

8. The method of fabricating a semiconductor device according to claim 1, further comprising:

forming a conductive layer on a gate insulating film on the semiconductor substrate,

forming a layer for defining a mask on the conductive layer,

etching the conductive layer through a mask of the layer for defining a mask, thereby forming a gate electrode, and

removing the layer for defining a mask remaining on the gate electrode after formation of the gate electrode, wherein

the first part of the wafer includes the layer for defining a mask,
the second part of the wafer includes the gate insulator film, and
hydrofluoric acid gas is supplied as the gas for etching to remove the layer
for defining a mask.

9. The method of fabricating a semiconductor device according to claim 8,
including repeatedly supplying the gas for etching.

10. The method of fabricating a semiconductor device according to claim 9,
including evacuating the chamber, and alternatively supplying the gas for etching and
evacuating the chamber.

11. A wafer treatment apparatus for treating a first part of the wafer having a first
etching property and a second part of the wafer having a second etching property,
different from the first etching property with a gas for etching, comprising:

a chamber for holding a wafer;
an etching gas supply part supplying the gas for etching into said chamber; and
a control part controlling supply of the gas for etching from said etching gas
supply part into said chamber, wherein said control part, assuming that a time between
introduction of the gas for etching into said chamber and starting of etching of the first
part of the wafer is a first starting time and a time between introduction of the gas for
etching into said chamber and starting of etching of the second part of the wafer is a
second starting time, longer than the first starting time, supplies the gas for etching from
said etching gas supply part into said chamber for a time longer than the first starting time
but shorter than the second starting time.

12. The wafer treatment apparatus according to claim 11, wherein the time
difference between the first starting time and the second starting time is not more than
about 5 seconds.

13. The wafer treatment apparatus according to claim 11, further comprising an added gas supply part supplying a reaction accelerating gas, for reducing the first starting time, into said chamber, wherein said control part supplies the reaction accelerating gas from said added gas supply part into said chamber before supplying the gas for etching.

14. The wafer treatment apparatus according to claim 13, wherein said control part alternately supplies the gas for etching and the reaction accelerating gas.

15. The wafer treatment apparatus according to claim 13, wherein said control part supplies the reaction accelerating gas while supplying the gas for etching.

16. The wafer treatment apparatus according to claim 11, further comprising an evacuation part evacuating said chamber, wherein said control part prevent said evacuation part from operating while supplying the etching gas.

17. A method of cleaning a wafer after formation of a gate electrode, including removing a reaction product formed by etching with hydrofluoric acid gas, after forming the gate electrode that has been patterned by the etching with a mask on a semiconductor substrate, through a gate insulating film.

18. The cleaning method according to claim 17, including removing the reaction product with hydrofluoric acid gas within a reaction time difference between a time when the reaction product is etched by the hydrofluoric acid gas and a time when the gate insulating film is etched by the hydrofluoric acid gas.

19. The cleaning method according to claim 18, wherein the reaction time difference is repetitively set, thereby removing the reaction product with the hydrofluoric acid gas.

20. The cleaning method according to claim 19, wherein a semiconductor substrate including the gate electrode is set in a chamber, and the reaction time difference is repetitively set by repeatedly evacuating the chamber and charging the chamber with the hydrofluoric acid gas.